Report from sub-groups
Cryogenic
Cryogenic payload

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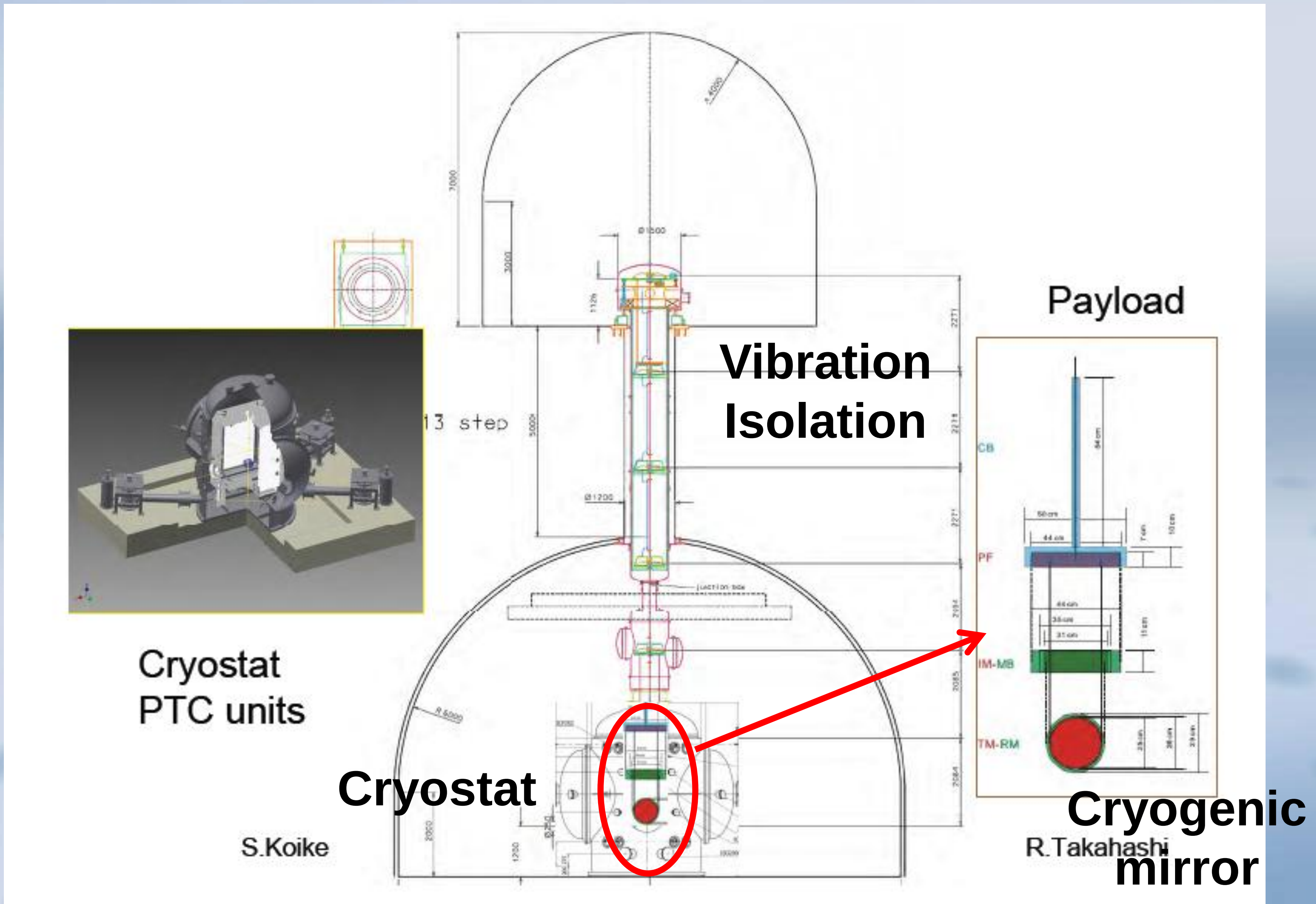
the University of Tokyo

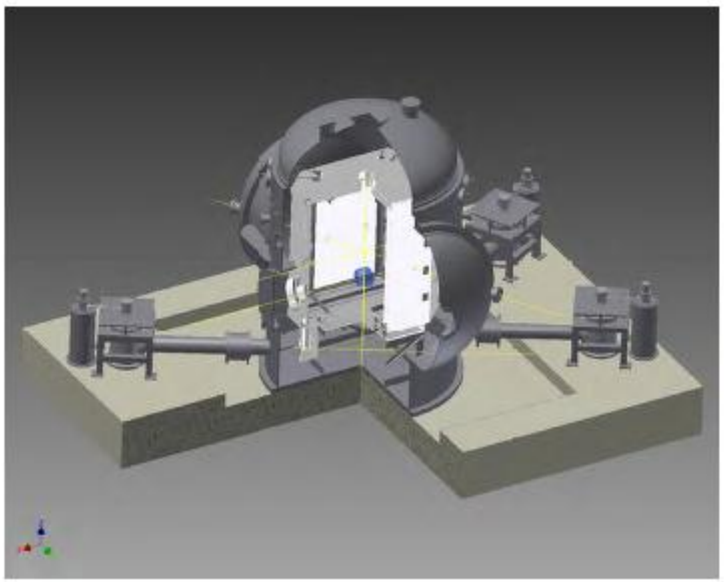
KAGRA face to face meeting
Institute for Cosmic Ray Research, Kashiwa, Japan
31 July 2012

What is cryogenic payload ?

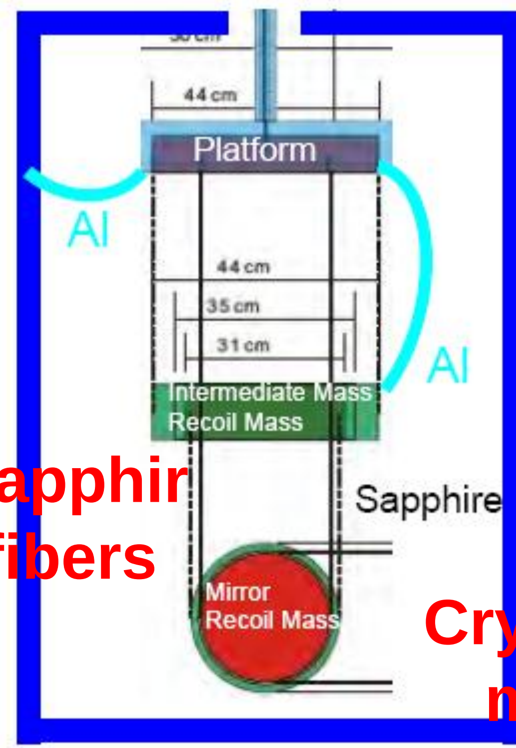


What is cryogenic payload ?

Cooling of payload



Double radiation shield
Low vib. PTC units
Pure Al heat path



What are issues ?

(1)How to assemble and install
(2)Strength
(3)Control and damping system
to reduce fluctuation and instability
(4)Cooling
(5)Noise

Outline of strategy

The development should be in progress for bKAGRA (2016-) in iKAGRA phase.

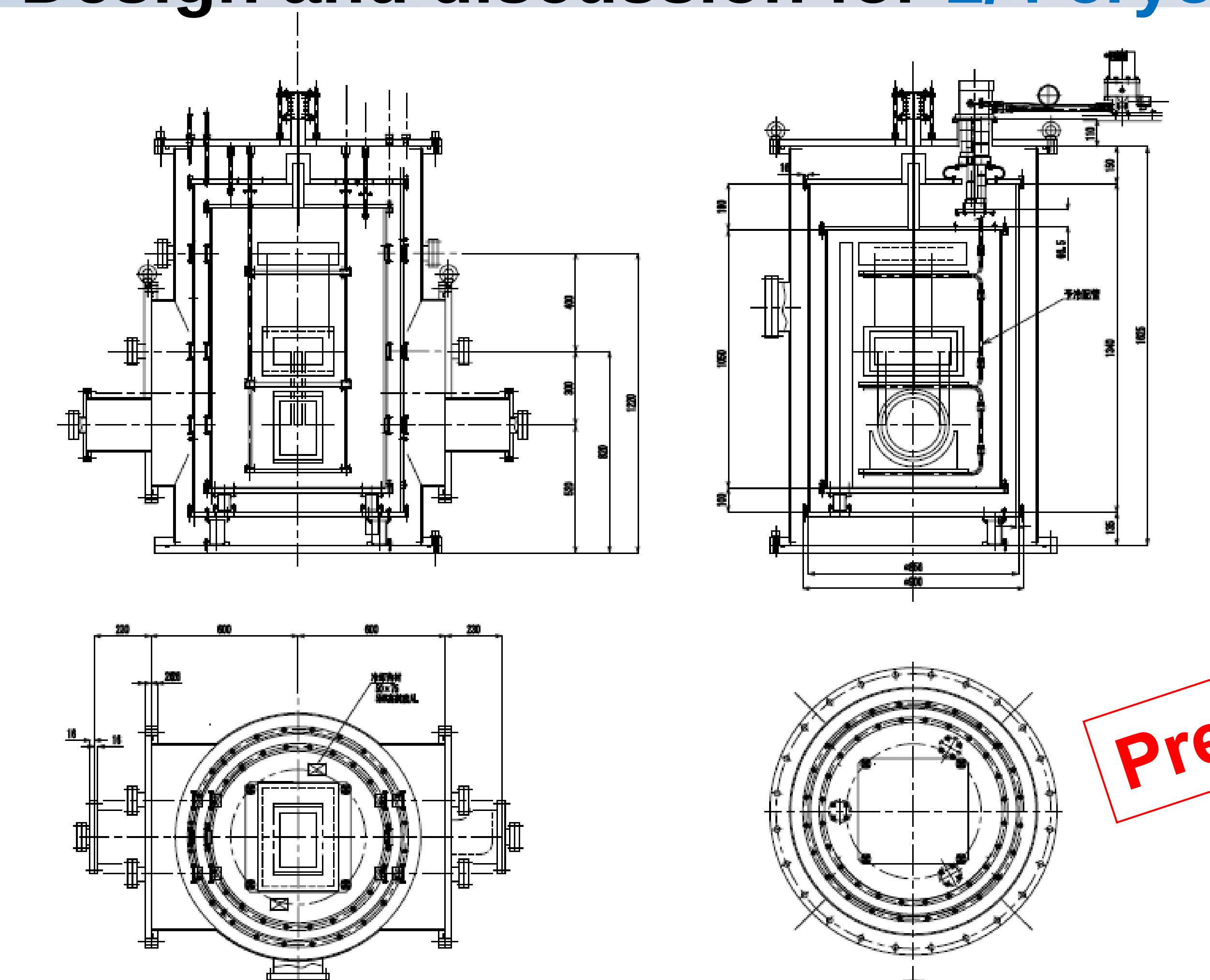
In iKAGRA phase (before installation in mine)

(a) Experiment of 1/4 cryostat in ICRR to check payload performance
1/4 means number of cryocooler, not size.
(b) Other R&D

1/4 cryostat

Preparation for 1/4 cryostat

Design and discussion for 1/4 cryostat



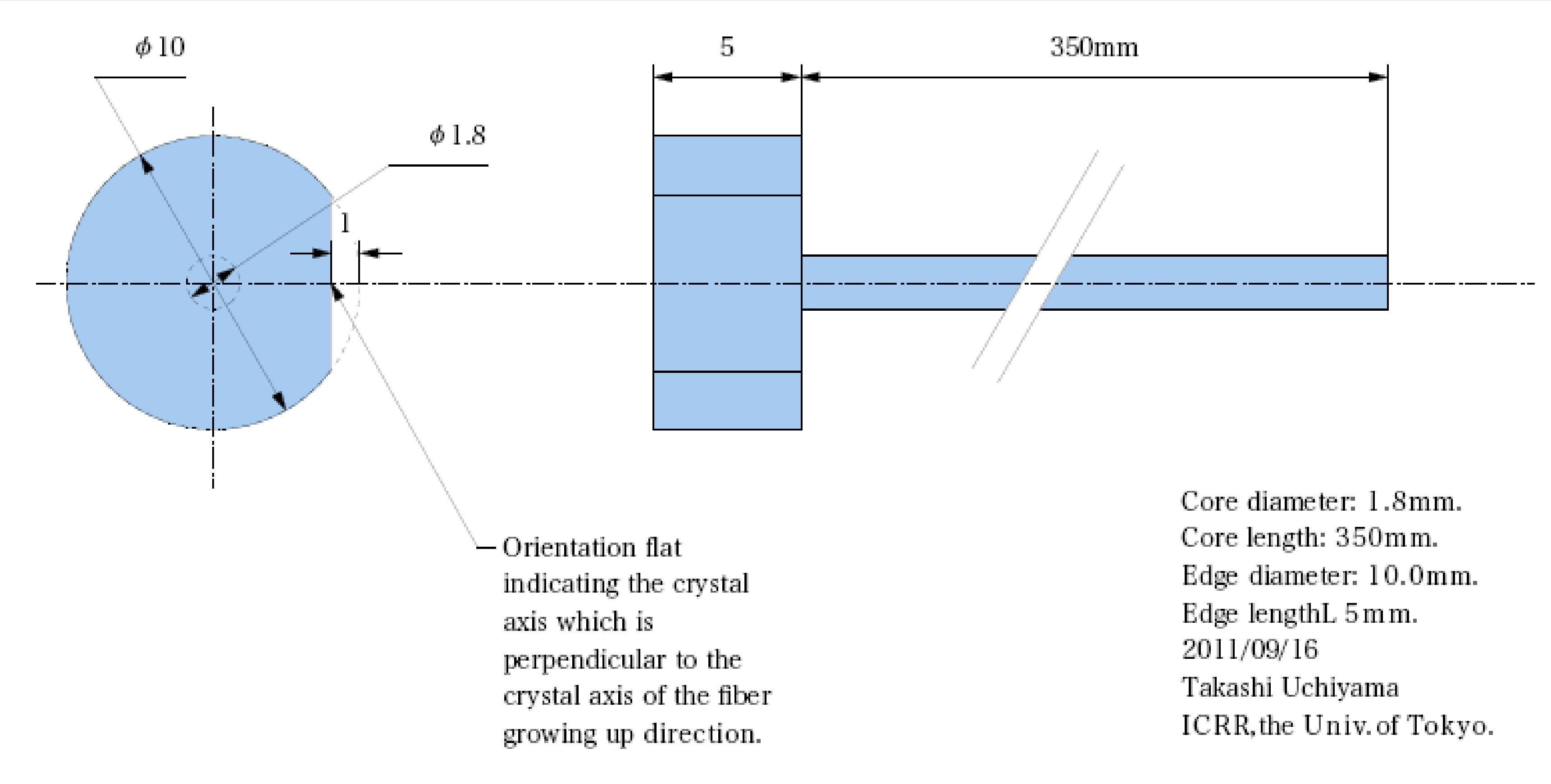
to check payload is in progress.

Preliminary.

Sapphire fiber

1. Fibers with nail heads

Test sample (T. Uchiyama)



Sapphire fiber

1. Fibers with nail heads

T. Uchiyama asked MolTech GmbH (Germany).
Sapphire fibers have already come !

Length = 350 mm diameter = 1.8 mm
Almost as needed in bKAGRA.
Need to check the quality and improvement (T. Ushiba, K. Shibata).

Sapphire fiber

1. Fibers with nail heads

Ettore Majorana asked IMPEX HighTech GmbH (German company).

They can make similar fibers (nail heads on the both ends).

Shoter fibers (about 100 mm in length) will arrive at ICRR on beginning of September.

Sapphire fiber

2. Measurement

Thermal conductivity : T. Ushiba
Q-value : K. Shibata

Sapphire fiber

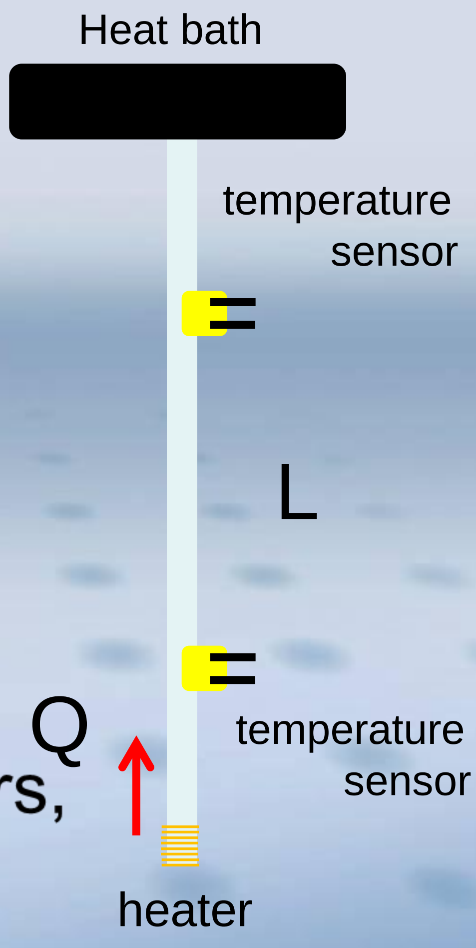
2. Measurement Thermal conductivity (T. Ushiba)

- Sample size

  diameter : $\phi 1.8\mathrm{mm}$

  sample length : 100mm
- One dimensional approximation.

$$\kappa = \frac{LQ}{A\Delta T}$$



κ :thermal conductivity

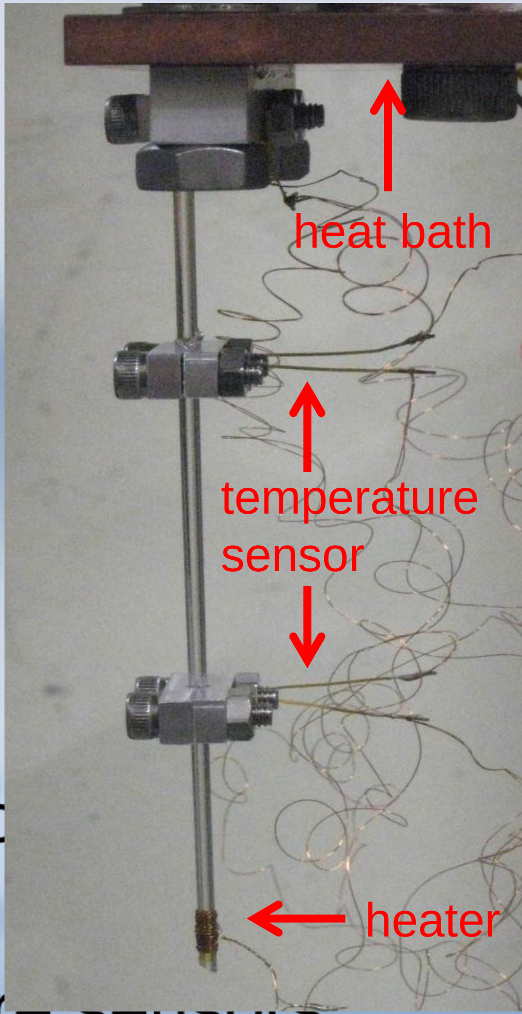
L :length between two temperature sensors,

Q:heat flow, A :sample cross section,

ΔT:difference of values of two temperature sensors

Sapphire fiber

2. Measurement Thermal conductivity (T. Ushiba)



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Sapphire fiber

2. Measurement Thermal conductivity (T. Ushiba)

- We measured the thermal conductivity of Photoran's sapphire rod without nail head whose surface is polished (before we try measurement for Moltech and IMPEX fibers). The diameter of the rod is 1.8 mm.

Result

700 W/m/K @ 12K

1100 W/m/K @ 17.5 K

Compared with Tomaru's previous measurement, our result is a bit small.

Sapphire fiber

2. Measurement Thermal conductivity (T. Ushiba)

Something to be considered as the reason why the value of this measurement is small

•the purity of the sapphire rod

So, we now measure thermal conductivity near 30 K (the peak of sapphire thermal conductivity) and confirm the purity is well or not.

If the purity of sapphire rod is not enough well, the peak of the thermal conductivity is gentle.

Sapphire fiber

2. Measurement Q-value (K. Shibata)

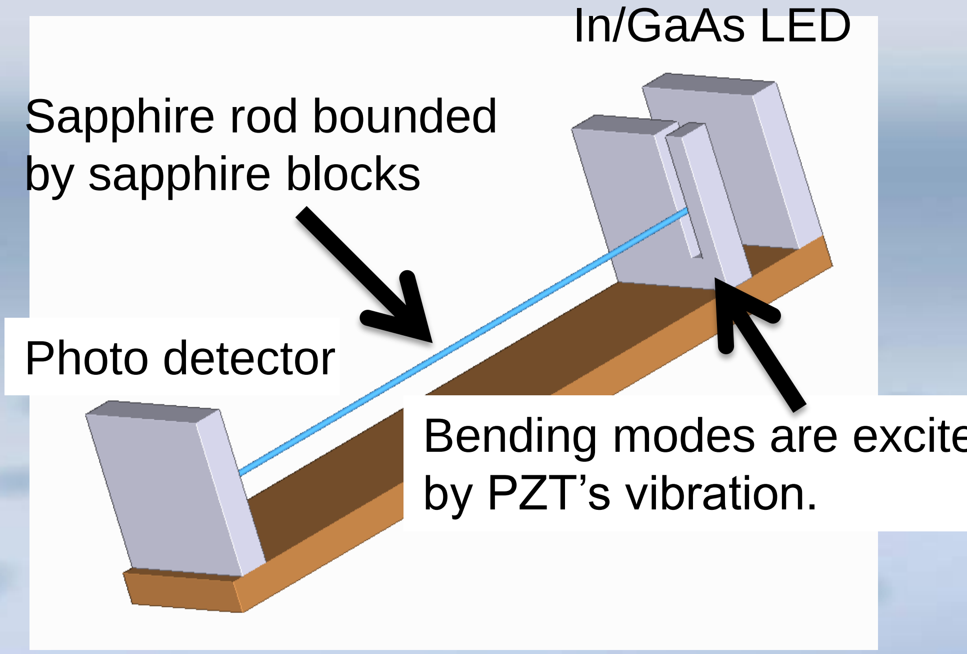
- In KAGRA, we use sapphire rods to suspend mirrors.
- The mechanical-Q of its bending modes are high. But it may depends on the surface condition. e.g.) as grown or polished, what manufactured it.

Moltech Sapphire rod φ1.8mm

Sapphire fiber

2. Measurement Q-value (K. Shibata)

- We need to measure the mechanical-Q around 14-20K in advance.
- By vibrating the supported point, we excite the bending modes. The amplitude is measured by the shadow sensor, and from the decay time, we estimate the mechanical-Q.
- This experiment is done in KEK and will be finished by the end of this summer.



Vibration of shield

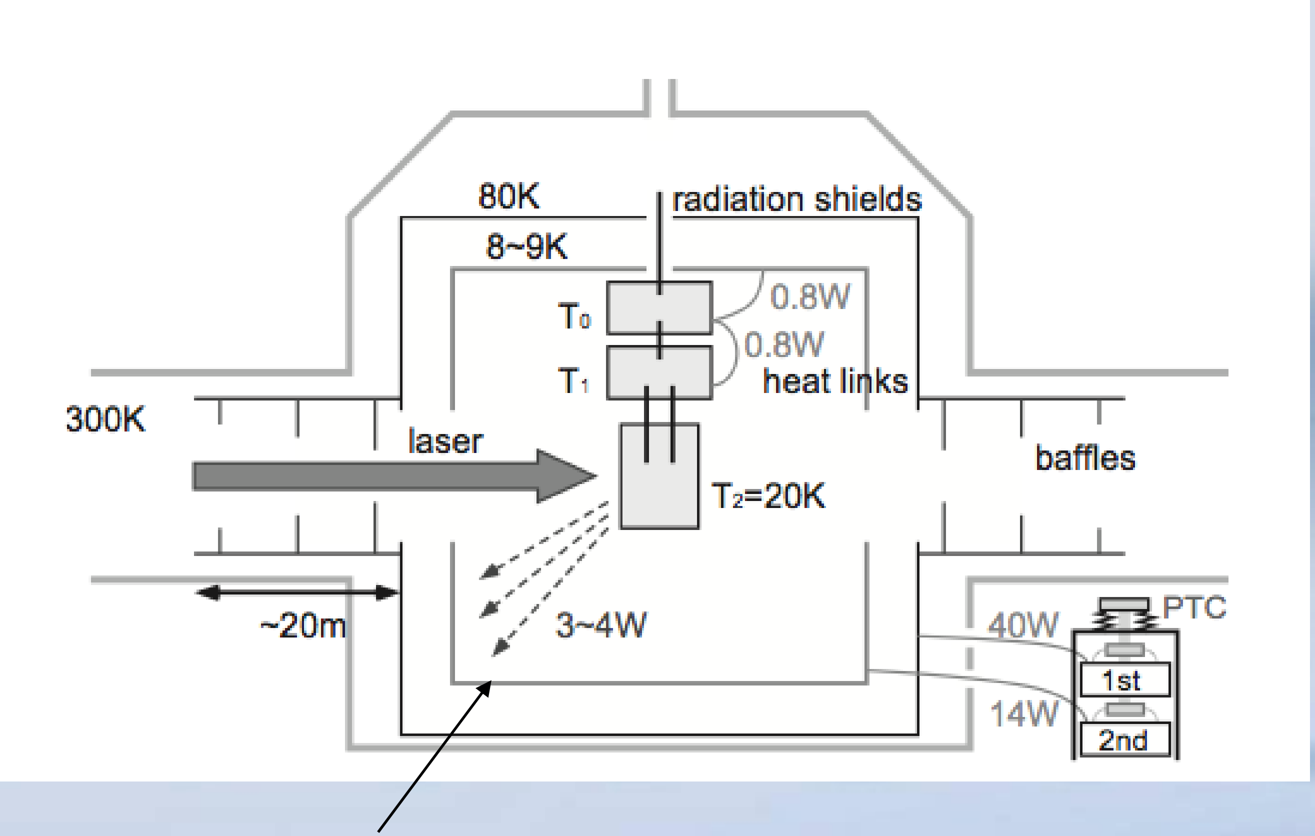
Sekiguchi's calculation for vibration via heat links

Assumption : Vibration of heat link anchor in radiation shield is the same as that of CLIO (JGW-G0600422).

However, the vibration of anchor point depends on the structure of shield. Luca Naticchioni (vertical) and Dan Chen (horizontal) will measure vibration of radiation shield of KAGRA cryostat on this autumn.

Vibration of shield

Dan Chen

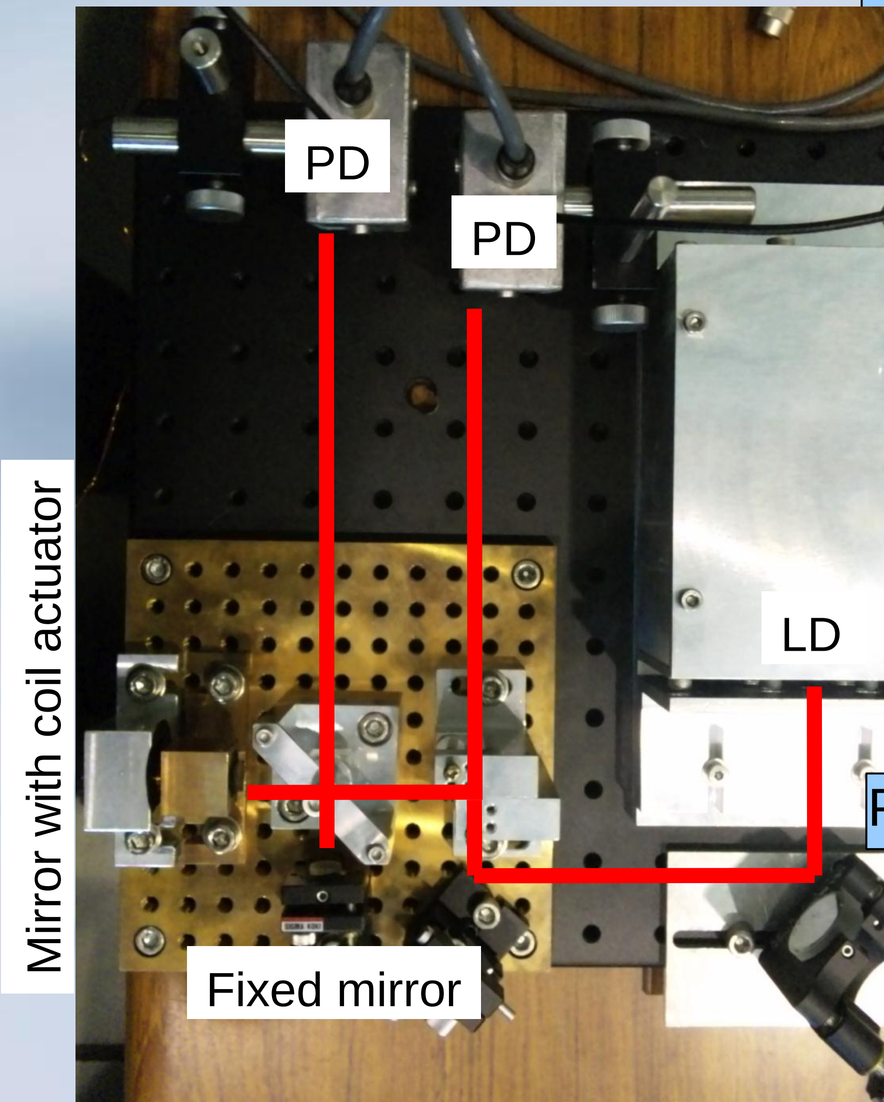


Measurement of the vibration on this radiation shields with cryocooler ON..
This vibration is expected to be same with the ground.
The vibration of the radiation shield may swing the test mass through the heat links.

Vibration of shield

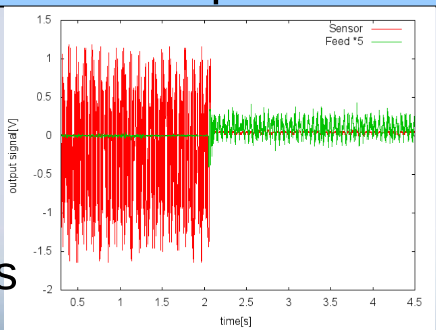
Dan Chen

We will use a MI to construct an accelerometer.



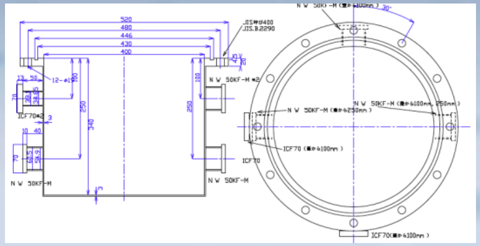
Accelerometer test at room temperature

Control test for circuits



Cooling test of the accelerometer

We will make a chamber for cooling test.



The design is fixed.

Preparation for the measurement in Toshiba

We will prepare
a optical fiber for this MI
in cryostat.

We are waiting an estimate sheet.

Initial cooling time

Initial cooling time of KAGRA cryostat and cryogenic payload is about 2 months (if no tricks).

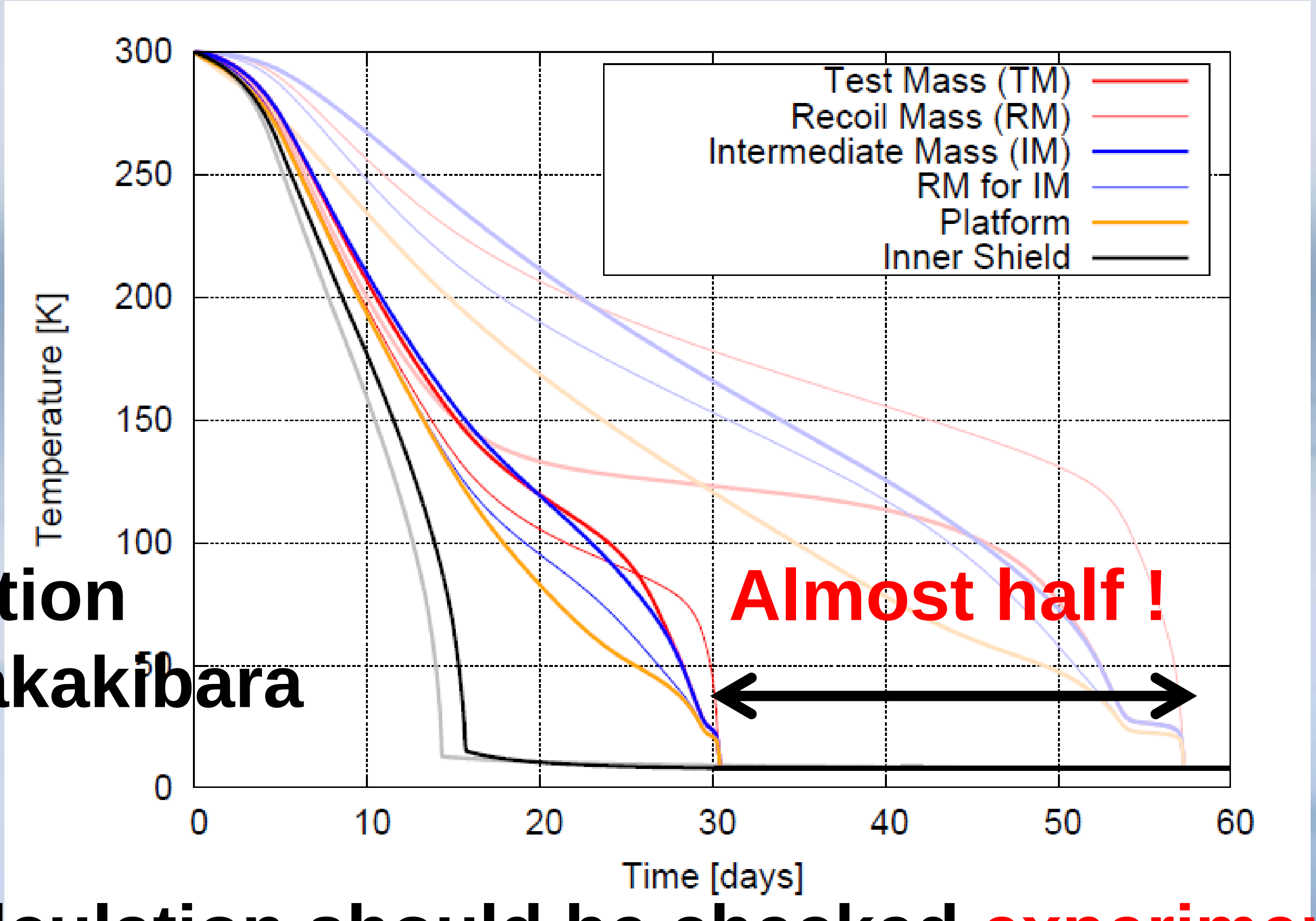
At beginning of initial cooling,
heat transfer is dominated by radiation.

Diamond Like Carbon (DLC) coating
(High emissivity, Large radiation)
on shields and payload (except for mirror)

Y. Sakakibara's Master thesis (English)
http://gwdoc.icrr.u-tokyo.ac.jp/DocDB/0008/P1200862/001/mthesis_sakakibara.pdf

Initial cooling time

Initial cooling time with DLC (shield and mass)



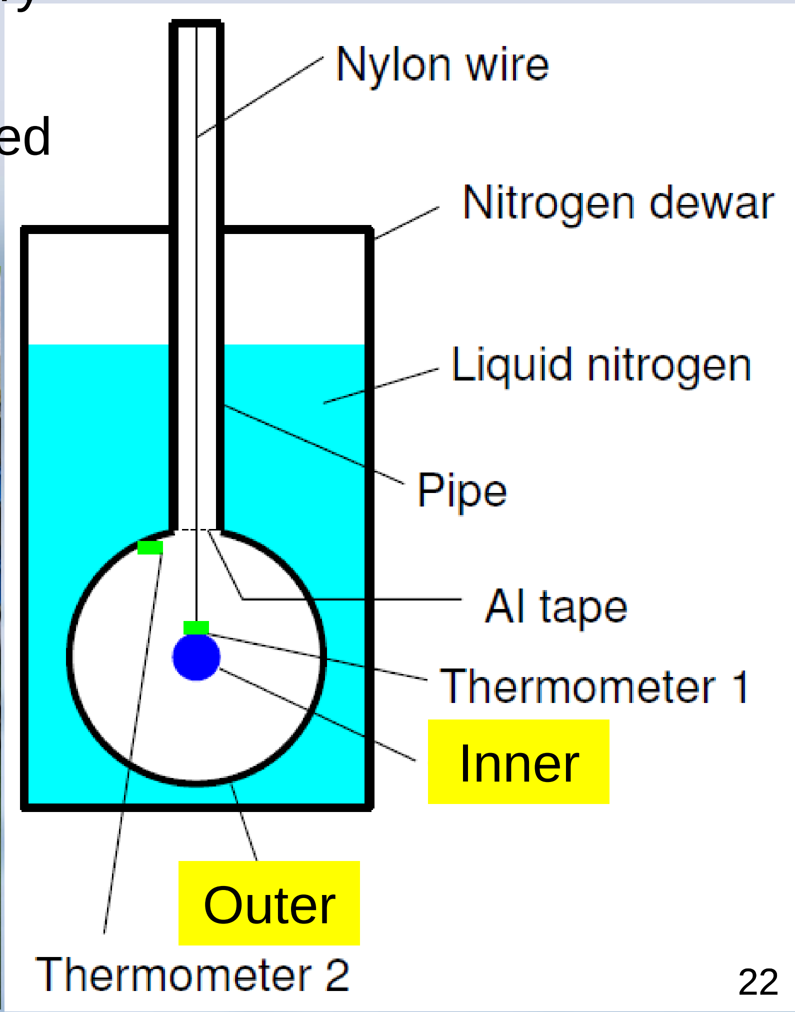
Calculation by Y. Sakakibara

This calculation should be checked experimentally.

Initial cooling time

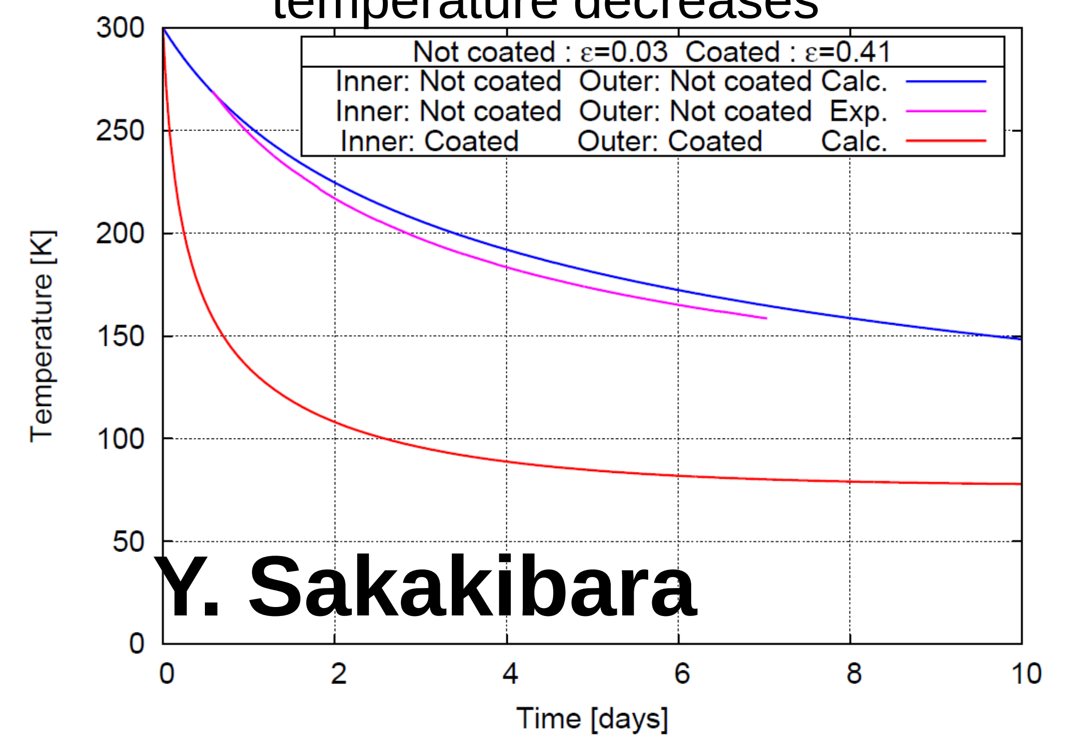
- High emissivity coating can increase cooling by radiation
  - Calculation shows initial cooling time is reduced by approximately half
  - Experimental verification is necessary
- Results to be compared
  - Outer : Not coated   Inner : Not coated
  - Outer : Not coated   Inner : Coated

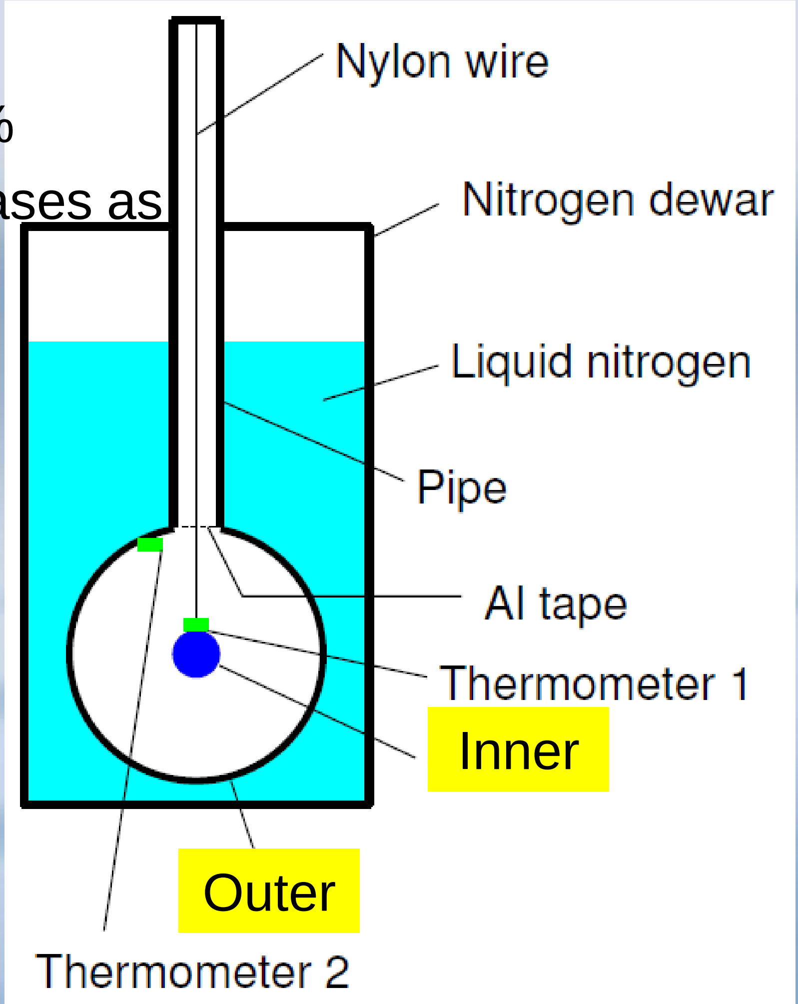
Y. Sakakibara



Initial cooling time

- Results so far
  - Outer : Not coated (A1070 +CP) emissivity ~0.03
  - Inner : Not coated (Copper) emissivity ~0.03
- Consistent with calculation
  - Within uncertainty of emissivity 30 %
  - Experiment shows emissivity decreases as temperature decreases





Y. Sakakibara

Baffle

Baffle for large angle scattering in cryostat

Optimal shape :

T. Akutsu

How to suspend :

K. Yamamoto

(JGW-G1201175

in Japanese)

Design from Mike Smith – Caltech

(support from LIGO and U.S. National Science Foundation)

Needs suspension inside radiation shield !

Other ideas for suspension

R. DeSalvo : composite mirror suspension
silicon blades, sapphire ribbon,
silicon hinge
His talk is on afternoon of 1st of Aug.

W. Johnson : metal wire and sapphire ribbon
JGW-G1201127

Meeting

Cryogenic payload meeting

Language : English
In usual case, 10am, the first Wednesday of every month (JST)

http://gwwiki.icrr.u-tokyo.ac.jp/JGWwiki/LCGT/subgroup/vacuum

Mailing list : kagra-cryopayload

Anybody is welcomed !

Collaboration

ELiTES: K. Somiya and K. Yamamoto explained on this morning.

University of Toyama

Toyama : Nearest large city to Kamioka (one hour drive)

Workshop for new collaboration with University of Toyama was held on the 7th of July.

Collaboration

K. Yamamoto attended workshop.
Some people are specialists of cryogenic experiment.

K.Yamamoto visited their labs and discuss future collaboration.
Discussion is in progress.

Summary

1/4 cryostat : Design and discussion are in progress.

R&D item

- **Sapphire fiber with nail head from Moltech and IMPEX**
- **Thermal conducutivity of sapphire fiber**
- **Q-value of sapphire fiber**
- **Vibration of shield**
- **Inital cooling time**
- **Baffle in cryostat**

Other ideas for mirror suspension

Collaboration: ELiTES and University of Toyama

Thank you for your attention !